

This is an open book assessment. You may consult any of your own notes. **You must provide an explanation for all your answers in your own words.** This will vary from a few words to two to three sentences depending on the material. This will be to demonstrate your understanding of the course.

Do not just repeat answers from your notes without this explanation. Make sure your method of calculation is clearly shown.

If you make use of websites or textbooks to answer specific questions, you must list them at the end of the relevant answer.

Assessment information:

- This assessment is made up of 6 pages.
- **You must upload your answers via GradeScope to Minerva within 48 hours of the assessment being released.** You are advised to allow up to four hours to photograph your answers, and upload as a PDF to GradeScope. The upload link will be found in the Assessment section for each module on Minerva and will be available throughout the period of the assessment
- Although the upload is open for the full period of the assessment, you are advised that the assessment should only require 2 hours to complete.
- **Late submission of answers is not possible.**
- You must answer **all** of the questions in this assessment.
- You should cross out any work you do not want to be marked.
- You should indicate the final answer to each question by underlining it.
- As part of the process of submitted through GradeScope you must identify which questions are answered on which uploaded pages. You must also check that you have uploaded all the work you wish to be marked as part of this assessment and that the answers uploaded are clearly legible. Failure to do so may result in your work not being marked.
- This is a formal University assessment. **You must not share or discuss any aspect of this assessment, your answers or the module more generally** with anyone whether a student or not during the period the assessment is open.

Approximate values of some constants

Speed of light in a vacuum, c	$2.998 \times 10^8 \text{ m s}^{-1}$
Electron Charge, e	$1.602 \times 10^{-19} \text{ C}$
Electron rest mass, m_e	$9.11 \times 10^{-31} \text{ kg} = 0.511 \text{ MeV c}^{-2}$
Proton rest mass, m_p	$1.673 \times 10^{-27} \text{ kg} = 938.3 \text{ MeV c}^{-2}$
Unified atomic mass unit, u	$1.661 \times 10^{-27} \text{ kg} = 931.494 \text{ MeV c}^{-2}$
Fine structure constant, α	$1/137.036$
Planck constant, h	$6.626 \times 10^{-34} \text{ J s}$
Boltzmann constant, k_B	$1.381 \times 10^{-23} \text{ J K}^{-1} = 8.617 \times 10^{-5} \text{ eV K}^{-1}$
Coulomb constant, $k = 1/4\pi\epsilon_0$	$8.987 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$
Rydberg constant, R	$1.09373 \times 10^7 \text{ m}^{-1}$
Avogadro constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Gas constant, R	$8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
Stefan Boltzmann constant, σ	$5.670 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Bohr magneton, μ_B	$9.274 \times 10^{-24} \text{ J T}^{-1}$
Gravitational constant, G	$6.673 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$
Acceleration due to gravity, g	9.806 m s^{-2}
Permeability of free space, μ_0	$4\pi \times 10^{-7} \text{ H m}^{-1}$
Permittivity of free space, ϵ_0	$8.854 \times 10^{-12} \text{ F m}^{-1}$
1 Parsec, pc	$3.086 \times 10^{16} \text{ m}$
Solar mass, M_\odot	$1.99 \times 10^{30} \text{ kg}$
Magnetic flux quantum, Φ_0	$2.0679 \times 10^{-15} \text{ Wb}$

Some SI prefixes

<i>Multiple</i>	<i>Prefix</i>	<i>Symbol</i>	<i>Multiple</i>	<i>Prefix</i>	<i>Symbol</i>
10^{-18}	atto	a	10^{-9}	nano	n
10^{-15}	femto	f	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T

SECTION A

- **You must answer all the questions from this section.**
- **This section is worth 20 marks.**
- **You are advised to spend 30 minutes on this section.**

A1. Q1.

[7 Marks]

A2. Q2 etc

[7 Marks]

SECTION B

- You must answer all the questions from this section.
- This section is worth 60 marks.
- You are advised to spend 90 minutes on this section.

B1.	(a) Part a here	[4]
	(b) Part b	[8]
	(c) Part c	[5]
	(d) part d	[13]
		[20 Marks]

B2. (a) Next Q part a etc

[20]

[20 Marks]

B3. (a) Next Q part a etc

[20]

[20 Marks]